Forest Health Protection
Pacific Southwest Region

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To: Field Manager, Bureau of Land Management, Eagle Lake Field Office, Susanville, CA

Subject: Evaluation of white fir stands on Fredonyer Peak (FHP Report NE10-10)

At the request of Wade Salverson, Forester, Eagle Lake Field Office, Bureau of Land Management, Bill Woodruff, Forest Health Protection (FHP) Plant Pathologist, and Danny Cluck, FHP Entomologist, conducted a field evaluation of the Fredonyer Peak project area on August 6, 2010. The objectives of this site visit were to evaluate the current white fir (*Abies concolor*) stand conditions and identify any current or potential forest insect and disease problems. Observations and recommendations presented in this evaluation will assist the Field Office with silvicultural prescriptions for a proposed timber harvest within these stands.

Background

The Fredonyer Peak project area is located in an isolated patch of eastside mixed conifer forest type surrounded by western juniper (*Juniperus occidentalis*) and sagebrush (*Artemisia* spp.) steppe habitats about 3 miles east of Eagle Lake, CA, at an elevation range of 6700 to 7700 feet (T33N, R12E). Annual precipitation for the area is approximately 20 - 25 inches. This isolated forest is comprised of mainly small sawlog and pole sized white fir at the upper elevations and a mix of small sawlog and pole sized white fir, Jeffrey pine (*Pinus jeffreyi*) and ponderosa pine (*Pinus ponderosa*) at the lower elevations. A few >24" DBH white fir and several pockets of dense white fir saplings are scattered throughout the project area along with a shrub component of curlleaf mountain mahogany (*Cercocarpus ledifolius*) and snowbrush (*Ceanothus velutinus*). Snowbrush is prevalent in areas of past white fir mortality and subsequent salvage harvest where canopy cover was significantly reduced (two sales occurred in the mid and late 1990's after the

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protracted drought period of 1987 to 1992). Jeffrey and ponderosa pine saplings, planted within these salvage harvested areas, are now experiencing excessive competition from the established snowbrush. Management objectives for the site are to reduce stand density through the removal of sawlogs and biomass. This will decrease the risk of stand replacing wildfire and improve the health and vigor of residual trees.

Observations

Many stands of white fir are in an overstocked condition. Areas where stocking appears to be more suitable for the site are associated with past tree mortality and subsequent salvage logging and along the forest margins where white fir is growing with mountain mahogany.

Conks of Heterobasidion root disease (*Heterobasidion occidentalis*) were observed on the western side of Fredonyer Peak in an old white fir stump (Figure 1).

Most of the older white fir (~250 years old) had evidence of heartwood decay in areas of old fire scars or mechanical injury from past harvest activities.

Evidence of old, approximately 3 years, white fir sawfly (*Neodiprion abietis*) defoliation was observed on the western side of the mountain.

Dead tops and some whole tree mortality of white fir in all size classes, caused by the fir engraver beetle (*Scolytus ventralis*), were observed throughout the project area (Figure 2).

Figure 1. Fruiting bodies, or conks, of *Heterobasidion occidentalis*, the causal agent of Heterobasidion root disease.

Figure 2. Dead tops and whole tree mortality of white fir caused by the fir engraver beetle.

Discussion and Recommendations

White fir and white fir/Jeffrey pine/ponderosa pine stands

White fir mortality has increase over the past two years throughout northeastern California as a result of drier than normal conditions. For example, the Palmer Hydrological Drought Index

(PHDI) for Division 3, which encompasses the area of Fredonyer Peak, has registered dry conditions each year for 2007 – 2010. Conditions for 2008 and 2009 were considered moderate drought (Table 1).

Table 1. Palmer Hydrological Drought Index (PHDI) 2007-2010.

YEAR	PHDI
2007	-1.01
2008	-2.67*
2009	-2.75*
2010	-1

*PHDI values ranging from -2.00 to -2.99 are considered moderate drought conditions. Severe drought conditions range from -3.00 to -3.99 and extreme drought conditions are below -4.00.

White fir that succumb to fir engraver beetle attacks are typically predisposed by other factors that compromise their health and vigor. In the Fredonyer Peak area, high stand density (in some areas), prolonged drought and annosus root disease are all contributing factors in declining tree health. White fir trees in the Fredonyer Peak area will remain susceptible to high levels of mortality until the current drought conditions subside. More top kill and additional whole tree mortality should be expected next summer due to fir engraver beetle attacks sustained in 2010. If the area receives normal to above normal precipitation this winter, some white fir may be able to replenish their defense systems and resist further attacks. Some trees will require more than one season with adequate moisture before they will fully recuperate their natural defenses.

Fredonyer Peak's average annual precipitation of 20 – 25" is below what is generally required to sustain white fir over a generation. Therefore, even with lower stocking levels, white fir growing on this site is at a higher risk for fir engraver beetle caused mortality. High stand density combined with the last prolonged drought (1987-1992) resulted in elevated levels of white fir mortality throughout the project area as evidenced by older dead and down stems from that period and the need for two salvage harvest entries in the 1990's.

The distribution of both white fir and white fir mortality are strongly influenced by the mean annual precipitation. The lower limit of precipitation in the natural range of white fir is about 20 inches (Fowels, H.A. 1965). An isohyetal map of mean annual precipitation can be used to rate the risk of white fir mortality (Schultz 1994, FHP Report 94-2).

> **Low risk: 40+ inches annual precipitation.** These areas easily support stands of white fir and red fir. Mortality will be low, even during drought periods. Thinning will increase the rate of tree growth, but will show only slight differences in tree mortality.
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> **Medium Risk: 30-40 inches of annual precipitation.** Stands in these areas often have a high percentage of white fir. White fir may achieve a considerable age and size in these areas. Prolonged drought may cause mortality of 5-10% of the stems. Periodic thinning which concentrates on removing white fir ingrowth will lower mortality by maintaining a more sustainable amount of biomass, as well as promoting a more stable mixed species stand.

High Risk: 25-30 inches of annual precipitation. In the absence of fire, these areas have stands which are dominated by densely stocked, small diameter white fir. The species distribution by age class shows an increase in the relative percentage of white fir in these stands following fire suppression. Prolonged drought may cause mortality in excess of 50% of the stems. The risk of mortality can be lowered by thinning to a wide spacing prior to the onset of drought, and by promoting a mix of species that are native to the site.

Extreme risk: 20-25 inches annual precipitation. In some cases the shade tolerant trees may live long enough to achieve an intermediate of co-dominant crown position. Prolonged drought may cause mortality of 80-85% of the stems. In stands where the total stocking of both overstory and understory is high, mortality may also occur in the pines. The risk of mortality may be lowered by managing groups of pine at wide spacing.

A white fir levels of growing stock study conducted by Cochran (1998) on the Deschutes and Fremont National Forests between 1983 and 1995 provides some additional information to consider when managing white fir in lower precipitation areas. Plots were thinned in 1982 and again in 1985 to a residual stand density index (SDI) of 112, 168, 224 or 280. These corresponded to growing stock levels of 20, 30, 40 or 50 percent of normal density. Elevations for his study plots ranged from 4,500 to 5,900 feet with average annual precipitation ranging from 16 to 31 inches. A general drought prevailed over the study areas from the late 1970's to the mid 1990's and mortality between 1991 and 1995 destroyed the study. Mortality on Blocks 2, 3 and 4 of the study was attributed to fir engraver beetles. Mortality from fir engraver beetles appeared to increase with increasing stand densities and was above acceptable levels even at the lowest stand density (20 percent of density considered normal for white fir).

Healthy stands of white fir grow very rapidly, produce a dense crown cover and are visually pleasing (Cochran 1998). His results, however, raise doubts about maintaining stands with a large component of white fir in areas with mean annual precipitation rates below 32 inches even if stand densities are kept very low. Cochran's study stands grew well for more than 60 years and reached commercial size before severe mortality occurred. With climate change predictions of warmer and possibly drier conditions in the future, risk of white fir mortality in these areas will likely become even greater.

Management Alternatives

(1) **No action**

The overstocked condition of white fir stands in the Fredonyer Peak area will persist and increase over time until future drought conditions (a periodic occurrence in northeastern California) trigger excessive fir engraver beetle caused mortality. Furthermore, even with lower stand densities, the low annual average precipitation for this site put white fir at extreme risk of mortality whenever these drought periods occur. Although some mortality may be desired for snags, small openings and for future down woody debris, the no action alternative will most likely result in unacceptable levels of tree mortality and fuel accumulation.

(2) **Thinning**

Thinning white fir to a stand density well below the normal stocking levels for the species would reduce tree competition for limited water and nutrients but may not reduce mortality during extreme drought events in this drier area. For this reason, consideration of basing white fir thinning prescriptions on the normal stocking levels for Jeffrey pine and/or ponderosa pine is highly recommended. Furthermore, selecting for more drought tolerant species such as Jeffrey pine and ponderosa pine over white fir for retention will increase species diversity and make the stand more resilient to disturbance agents such as insects, disease, and fire. Thinning can also decrease the need to enter stands to conduct salvage operations and decrease the amount of fuel loading. This strategy of changing the species composition trajectory from white fir to more drought tolerant pine species and thinning to lower stocking levels should increase stand resiliency and mitigate potential impacts of future warmer and drier climate scenarios.

Jeffrey/ponderosa pine plantations

Jeffrey and ponderosa pine saplings planted subsequent to the 1990's salvage are experiencing severe competition from snow brush and other brush species (Figure 3). In order to increase growth and reduce the risk of losing planted trees to wildfire, mastication of all competing brush species is recommended.

Figure 3. Jeffrey/ponderosa pine plantations with severe brush competition.

If you have any questions regarding this report and/or need additional information please contact me at 530-252-6431.

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Appendix A – Insect and Disease Information

Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year, however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Heterobasidion Root Disease (formerly Annosus Root Disease)

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species: *Heterobasidion occidentalis* (also called the 'S' type) and *H. irregularis* (also called the 'P' type). These two species of *Heterobasidion* have major differences in host specificity. *H. irregularis* (‘P’ type) is pathogenic on ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentalis* (‘S’ type) is pathogenic on true fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentalis* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.